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Small mammal fauna of two abandoned field habitats, and a spatio-temporal analysis of four rodent populations

by
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Abstract: In the present study the authors investigate the small mammal fauna of two abandoned field habitats with different vegetation in the Dráva Lowlands, and the spatio-temporal changes of four rodent species found there, based on live-capture data from 1997-1998. The sampling areas are situated in the plain area of the rivulet Fekete-víz: one near the village Páprád, in a swampy area, which was not cultivated for four years, and the other near the village Nagycsány, in an area, which had been abandoned for one year. Based on their small mammal diversities, the two areas did not differ. Four species were captured in great numbers in both of the habitats: *M. arvalis*, *A. agrarius*, *A. sylvaticus* and *A. flavicollis*. For the characterisation of their dynamics, we applied minimum number alive (MNA) values, and for describing the spatial distribution of the individuals within the population, Lloyd's patchiness was used.
Keywords: live trapping, diversity, population dynamics, spatial distribution, *Apodemus*, *Microtus*

Introduction

Drawbacks from habitat fragmentation, and the formation of island characteristics appear nowadays as important factors from the point of view of the survival of communities (Soulé 1986, Harrison 1994). From the 1980s the metapopulation concept has gained strength also in small mammal ecology (Krohne 1897). As a result of human activities, natural and near-natural areas suffer fragmentation, and habitats composed of patches of various size are created that small mammals can utilise with characteristic spatial and temporal dynamics (Kozakiewicz 1995). From a metapopulation aspect, it is mainly the seasonal dynamics of *Clethrionomys glareolus* (Schreber 1780) that has been studied in patchy agrocenoses (Kozakiewicz & Gortat 1994), and also its space use in such patchy environments was analysed (Kozakiewicz *et al.* 1993). Lonan (1991a), too, investigated the small mammal communities of such fragmented habitats, with special attention to the dispersal dynamics of *Apodemus sylvaticus* (Linnaeus, 1758) in patches.

The small mammal fauna of a habitat complex similar to the areas subject to our studies were analysed by Pelikán & Nesvadbová (1979). The paper by Adamczewska-Andrzejewska *et al.* (1981) focuses on the relationship between three rodent populations (*Microtus arvalis* [Pallas 1779], *Apodemus agrarius* [Pallas 1771] and *Apodemus flavicollis* [Melchior 1834]) in cultivated lands; these species play a dominant role also in our sample community. The spatial organisation of the same communities was analysed by Adamczewska-Andrzejewska *et al.* (1979) and Mackin-Rogalska (1981). Hannsson (1968) conducted long-term population dynamical surveys in open habitats in Sweden, and he analysed separately the small mammal runways in abandoned areas (Hannsson 1987). Among the generalist, rather forest-dwelling species, it is *A. sylvaticus* the populations of which have been studied in open habitats (Jamon 1986, Loman 1991b, Fernandez 1996).

In Hungary Palotás (1986) performed removal and live-trapping investigations in 8 sample areas in the Hortobágy, a conclusion of which was the structural and dynamical description of the native small mammal communities. There he conducted trappings in several open habitats among which he selected an alfalfa field to represent agricultural areas, a riverside embankment to stand for temporary wintering habitat, and also two grasslands and a loess pasture.

The plant associations in our two selected open habitats are in different stages of succession, and from a landscape-ecological approach, these could be described as areas habitat fragments or habitats mosaic situated in between cultivated and abandoned fields of other nature. The present study aims at giving a comparison of the small mammal fauna of the two areas, and an analysis of the spatial and temporal dynamics of their four most frequent rodent species.

Material and methods

Study areas

The trappings were carried out in two open areas of different vegetation. These two sampling areas (***A***, ***B***) are described in the followings (Fig. 1).

A – 3-year old abandoned field with ruderal weed association

Fig. 1. Location of the two sampling areas in South Hungary

Agricultural cultivation in the area near the village Nagycsány was discontinued in 1995. Its most elevated point is near the road connecting Vajszló and Sellye, from where, gently sloping towards the south-southwest, its vegetation gradually transforms into a marshy association with *Calamagrostis epigeios* dominance. The vegetation does not form zones along the 100 meter long water-cover gradient. It is in the early stage of secondary succession, with a high degree of heterogeneity which is caused mainly by the random settling of colonising species. Environmental pressure and regulating mechanisms still have secondary importance in the formation of the patterns of the community. The patchiness of the patterns can be observed only at a small scale (1 m^2). Patches are generally monotypic, with shape and size variance originating from differences in the growth strategies of the plant species. Based on its physiognomy, the area can be divided into two parts, out of which the first is a double-level ruderal association. In its lower herb layer perennial weed-type dicotyledons are found forming a low (5–10 cm) and dense (80–100%) cover, with some of the generalists of the original marsh vegatation having grown to exist in masses. The most frequent species are *Trifolium pratense*, *Ambrosia elatior*, *Potentilla reptans*, *Stenactis annua*, *Stellaria media*, *Euphorbia cyparissias*, *Setaria viridis*, *Matricaria maritima*, *Consolida regalis*, *Anthemis arvensis*. Its upper layer consists of high weeds (60–100 cm high, 30–40% cover), with some marshland species having become dominant. The most characteristic frequent species are *Solidago gigantea*, *Cirsium arvense*, *Erigeon canadensis*, *Artemisia vulgaris*, *Daucus carota*, *Stenactis annua*, *Calamagrostis epigeios*, *Agrostis stolonifera*. The physiognomically different, other part of the area is a double-level association near the road, with a shrub layer just establishing itself. From the *Robinia pseudo-acacia* stand north of the road, seedlings have colonised and constitute a loose third layer (of 2–3 m heigth, 20–30% cover) on top of the two-level association.

B – 5-year old abandoned field with ruderal weed association

The sampling grid here was placed in an area where cultivation had been stopped four years before. It is in the surroundings of the village Páprád, and is mainly a double-level weed association with hay-meadow and marshland species, with no physiognomical patchiness. The lower herb layer is low (5–20 cm), with high degree of cover (150%), consisting mostly of dicotyledons, though at places monocotyledons also reach a considerable degree of cover. Its dominant species are: *Potentilla reptans*, *Veronica chamaedrys*, *Daucus carota*, *Plantago lanceolata*, *Trifolium pratense*, *Ranunculus acris*, *Centaurea jacea*, *Stenactis annua*, *Ranunculus repens*, *Agrostis stolonifera*, *Achillea millefolium*. The upper herb layer is a 70–100 cm high weed association with 50–70% cover. Its dominant species are: *Daucus carota*, *Cirsium arvense*, *Erigeon canadensis*, *Crepis tectorum*, *Calamagrostis epigeios*, *Artemisia vulgaris*, *Solidago gigantea*, *Valeriana officinalis*, *Urtica dioica*, *Centaurea jacea*. The shallow depressions found along the northern and western edges of the grid were covered with water after showers in the summer. Characteristic species are as follows: *Erigeon canadensis*, *Sambucus ebulus*, *Sambucus nigra*, *Lolium perenne*, *Daucus carota*, *Stellaria media*, *Dactylis glomerata*, *Chenopodium album*, *Cichorium intybus*, *Convolvulus arvensis*, *Setaria viridis*.

Trapping methods

For capturing small mammals, we used box-type live-traps. In both areas a 1 hectare grid of 11 stations by 11 stations (with traps positioned 10 m apart) was applied. Traps were baited with bacon and a grain mixture scented with vegetable oil and aniseed-extract. Except for the hot summer months (June, July and August), traps were operated throughout the day, and, accordingly, were checked twice daily (7.00 CET, 20.00 CET), totaling 9 consecutive checkings in each monthly session. In the summer period we checked the traps only once a day (in the morning), since during the daytime traps were left closed and were re-opened only at around 18.00–19.00, so as to protect the animals from being killed in the overheating compartments. For the individual identification of the captured animals we applied the removal of the terminal knuckle of toes (Begon 1979), and we recorded the sex (also gravidity or lactation in females), age and weight of the animals.

In the area situated near the village Nagycsány, which had been abandoned for a year at the beginning of our investigations (area ***A***), traps were operated from March through October both in 1997 and

1998, totaling 9680 trap nights. However, the area near the village Páprád (area B) went into private ownership in the meantime, allowing us only limited access to it: in 1997 there were three months (September, October, November), while in 1998 there were five months (from May through September) of 5-night trapping, all in all yielding 4840 trap nights.

Statistical methods

From the total number of captures we calculated the percentage rate of insectivores *(Insectivora)*, rodents *(Rodentia)*, and within those the percentage of genera, in both areas. For the characterisation and comparison of the small mammal communities in the two areas, data of corresponding months were used. Shannon-Wiener diversity and evennes of the sample areas were calculated (Pielou 1975). For the comparison of diversity values we applied t-test, and, with the help of Rényi's formula, diversity ordering was also carried out (Tóthmérész 1995, 1997). For these calculations the software package NuCoSA 1.0 was employed (Tóthmérész 1993, 1996).

Capture data were stored in a database and were analysed using the Manly-Parr diary-of-captures method. In both habitats MNA (minimum number alive) values were calculated for the four character populations (Petrusewitz and Andrzejewski 1962, Krebs 1966, Boonstra & Krebs 1978, Halle 1991). In the four dominant species population trends were compared in species-pairs, using Spearman rank-correlation (Zar 1996).

We also looked at the spatial distribution of individuals of the four populations in the two areas. For this purpose Lloyd's patchiness values (Lloyd 1967) were calculated for each month, as the quotient of mean crowding and mean density. If its value equals 1.0, individuals are randomly distributed. If patchiness is higher than 1, individuals of the population show aggregation, while in the case of values lower than 1, they are considered to be segregated. Regression analysis was used to test how the index of aggregation was correlated with the experienced changes in population sizes.

Results

Faunistical analysis of two abandoned field areas

During our trappings in site **A** we recorded 7 small mammal species from March to October 1997, and 8 species in the corresponding period of 1998: 2 species belonged to the order *Insectivora*, and 6 belonged to *Rodentia* (Tables 1–2).

Table 1. Capture and recapture numbers in the trapped species in habitat A, 1997 (N_c: number of captures, N_{rc}: number of recaptures)

Species	Month	March		Apr.		May		June		July		Aug.		Sept.		Oct.	
	Capture parameter	N_c	N_{rc}	N_c	N_{rc}	N_c	N_{rc}	N_c	N_{rc}	N_c	N_{rc}	N_c	N_{rc}	N_c	N_{rc}	N_c	N_{rc}
Insectivora																	
C. suaveolens		–	–	–	–	–	–	–	–	–	–	–	–	1	–	3	–
C. leucodon		–		–		–		–		–		–		–		1	1
Rodentia																	
M. arvalis		15	–	1	–	4	1	12	9	11	15	59	17	40	40	52	48
A. agrarius		15	6	1	–	3	3	12	–	11	4	59	23	40	12	52	28
A. flavicollis		–	–	3	1	5	1	8	5	17	6	12	4	29	11	65	41
A. sylvaticus		8	1	1	–	10	6	20	8	24	9	19	9	31	16	27	13
M. minutus		2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
M. spicilegus		–	–	–	–	3	1	4	2	7	5	3	1	4	2	–	–

Table 2. Capture and recapture numbers in the trapped species in habitat A, 1998 (N_c: number of captures, N_{rc}: number of recaptures)

Species	Month	March		Apr.		May		June		July		Aug.		Sept.		Oct.	
	Capture parameter	N_c	N_{rc}	N_c	N_{rc}	N_c	N_{rc}	N_c	N_{rc}	N_c	N_{rc}	N_c	N_{rc}	N_c	N_{rc}	N_c	N_{rc}
Insectivora																	
C. suaveolens		1	1	–	–	–	–	–	–	1	–	–	–	13	–	6	–
C. leucodon		–	–	–	–	–	–	–	–	–	–	–	–	7	1	8	6
Rodentia																	
M. arvalis		25	–	9	–	12	9	15	9	57	15	65	17	44	40	48	30
A. agrarius		59	40	20	18	5	4	52	27	68	44	90	45	36	14	64	35
A. flavicollis		15	12	4	1	10	6	16	9	10	6	11	8	7	3	13	6
A. sylvaticus		2	1	2	2	1	1	11	4	8	5	7	3	10	6	6	4
M. minutus		–	–	–	–	–	–	–	–	–	–	–	–	3	–	1	–
M. spicilegus		–	–	–	–	3	–	1	–	2	–	–	–	–	–	–	–

In 1997 the genus *Apodemus* was represented at 14% higher than the genus *Microtus*; three species belonged to the former, and one species belonged to the latter (Fig. 2). If we look at the number of marked individuals in each species, it appears that *M. arvalis* was the dominant species of this abandoned area, besides *A. agrarius* (24.4% relative frequency), *A. sylvaticus* (15.2% rel. fr.) and *A. flavicollis* (16.1% rel. fr.). In 1998 the difference between the genera *Apodemus* and *Microtus* was even higher (23 %); in this trapping period representatives of the genus *Apodemus* were captured at an even higher rate (Fig. 3).

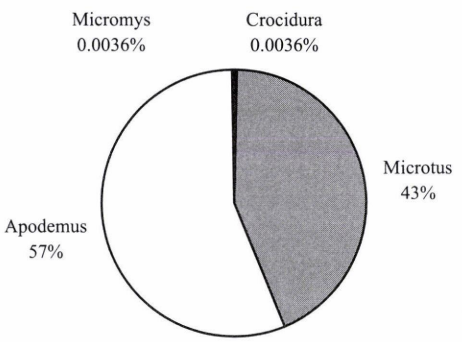

Fig. 2. Occurrence percentage in habitat **A** in 1997

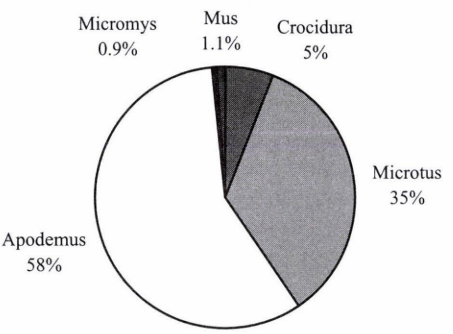

Fig. 3. Occurrence percentage in habitat **A** in 1998

Among them *A. agrarius* had the highest relative frequency (42.09%), whereas *A. flavicollis* gave 9.76% and *A. sylvaticus* gave 6.57% of the total number of individuals. Thus, in 1998 *A. agrarius* was the dominant species, as opposed to *M. arvalis*. From a faunistical perspective it is important to note that species belonging to the genus *Crocidura* (*Crocidura suaveolens* [Pallas 1811], *Crocidura leucodon* [Hermann 1780]) were present in much higher numbers in the second study year.

In site **B** we trapped 4 representative species of the order *Insectivora* and 5 species belonging to *Rodentia*. This totals to 428 marked individuals. As the areas become more and more marshy, both *Neomys* species (*Neomys fodiens* [Pennant 1771], *Neomys anomalus* Cabrera 1907) appear in higher densities (Tables 3–4).

Table 3. Capture and recapture numbers in the trapped species in habitat B, 1997 (N_c: number of captures, N_{rc}: number of recaptures)

Species	Month	September		October		November	
	Capture parameter	N_c	N_{rc}	N_c	N_{rc}	N_c	N_{rc}
Insectivora							
N. fodiens		1	–	2	–	1	1
N. anomalus		7	–	–	–	–	–
C. suaveolens		7	1	7	1	10	1
C. leucodon		7	3	25	14	18	14
Rodentia							
M. arvalis		45	1	56	11	31	10
A. agrarius		103	27	162	100	218	173
A. flavicollis		12	4	16	6	9	9
A. sylvaticus		20	4	14	7	6	4
M. minutus		2	–	5	–	–	–
M. spicilegus		–	–	–	–	–	–

Table 4. Capture and recapture numbers in the trapped species in habitat B, 1998 (N_c: number of captures, N_{rc}: number of recaptures)

Species	Month	May		June		July		Aug.		Sept.	
	Capture parameter	N_c	N_{rc}	N_c	N_{rc}	N_c	N_{rc}	N_c	N_{rc}	N_c	N_{rc}
Insectivora											
N. fodiens		–	–	–	–	–	–	3	–	1	–
N. anomalus		–	–	–	–	–	–	2	–	1	–
C. suaveolens		–	–	1	1	7	3	13	2	11	2
C. leucodon		–	–	1	–	11	6	21	10	12	7
Rodentia											
M. arvalis		–	–	1	–	1	–	35	4	40	8
A. agrarius		7	–	19	11	92	32	88	44	55	26
A. flavicollis		1	4	11	1	4	1	17	6	9	4
A. sylvaticus		2	–	1	–	11	–	2	3	2	1
M. minutus		–	–	–	–	–	–	–	–	1	–
M. spicilegus		–	–	–	–	–	–	–	–	–	–

In the course of trapping, the relative frequency of *A. agrarius* grew so that it was the most frequent species (55.3% rel. fr.), followed by *M. arvalis* (20.3%) (Fig. 4). In 1998 the difference between the representation of the genera *Apodemus* and *Microtus* did not change considerably, and even the increase of capture rates of *Crocidura* species (+5%) was not that marked as in site **A** (Fig. 5).

In this year too, both among the *Apodemus* species and among the entire small mammal fauna of the plot, *A. agrarius* was the most frequent species (with 49.68% of the total number of individuals). The relative frequency of *A. flavicollis* was 7.76%, while that of *A. sylvaticus* was 4.3%.

While the proportion of species belonging to the order *Rodentia* was higher in both study plots, it must be noted that the ratio of *Insectivora* was higher in Páprád (**B**) than in Nagycsány (**A**) (Fig. 6).

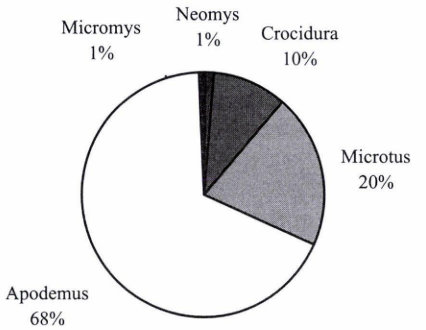

Fig. 4. Occurrence percentage in habitat **B** in 1997

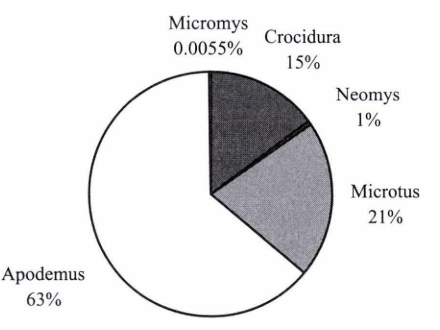

Fig. 5. Occurrence percentage in habitat **B** in 1998

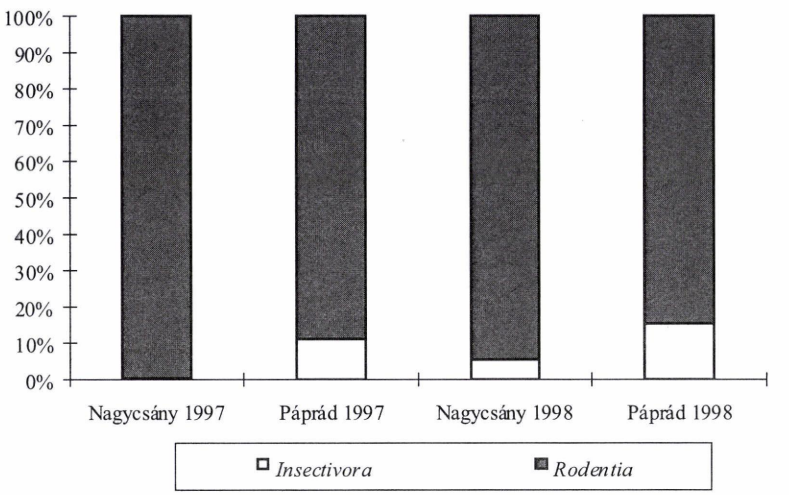

Fig. 6. Occurrence percentage of *Insectivora* and *Rodentia* in the two habitats (1997–1998)

Since the number of trap nights differed among the sample areas, for making comparisons we used the number of marked individuals per 100 trap nights, in addition to the number of species in the areas (Fig. 7).

The value of this index was much higher in 1997 in plot **B** than in the same area in 1998 or in plot **A** in either of the years the values of which are very close to each other. The striking value for plot **B** in 1997 was caused by the extremely high number of *A. agrarius* individuals caught during the three study months that year.

For calculating and ordering diversity values of the sample areas, data from corresponding periods of the two years were used. There was no significant difference between the 1997 and 1998 Shannon-diversity values of plot **A** ($H[S]_{1997} = 1.331$ vs. $H[S]_{1998} = 1.401$, $t = 1.578$, *NS*). In plot **B** near Páprád diversity could be calculated only for the September abundance values of the two years. Significant difference between diversity values of the years was not present here either (H[S]1997 = 1.449 vs. H[S]1998 = 1.484, t = 0.127, *NS*).

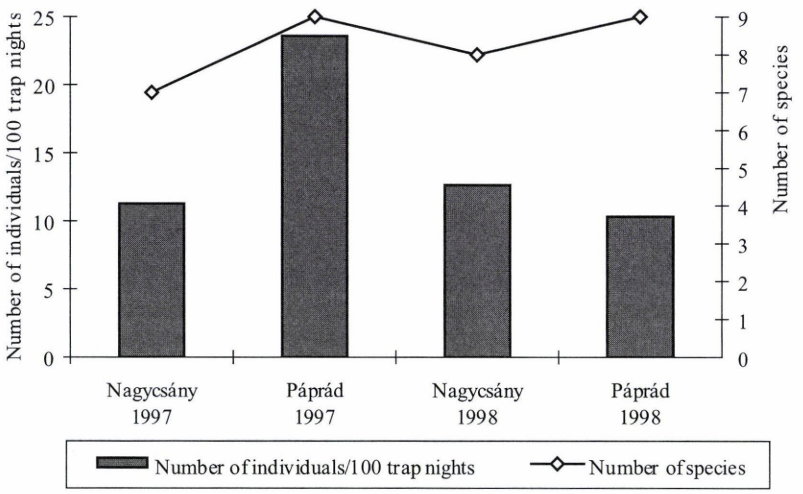

Fig. 7. Number of individuals/100 trap nights and number of speciesin the two habitats (1997–1998)

Although there were more species captured here, low diversity was caused by *A. agrarius* which had high relative frequency and was dispersing in great masses. There was no significant difference, in either of the two periods, when the diversities of the two plots were compared (1997: t = 1.052, *NS*, 1998: t = 0.757, *NS*). The t-test results were confirmed by the output of Rényi's diversity ordering. Diversity profiles intersect in both of the charts, with no significant difference between the 1997 and 1998 values in either of the areas (Fig. 8).

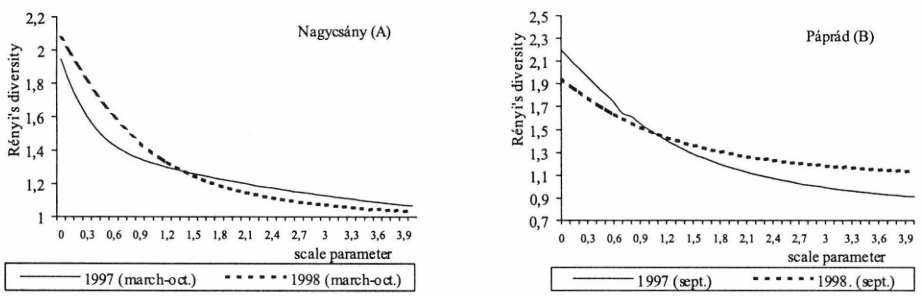

Fig. 8. Diversity ordering of the two sampling years in two habitats **A, B**

In the Nagycsány area (plot **A**) the difference between the two years was caused by the high number of *A. agrarius* and *M. arvalis* appearing in the second year, which reduced both diversity and evenness. Not even the appearance of shrews in plot **B** lead to a diffrence between the diversity of the areas, which fact, too, was a result of the high number of *A. agrarius*. The comparison of the two areas was based on trapping results from corresponding periods: September and October 1997, and from May to September 1998, respectively (Fig. 9). Both figures indicate that diversity profiles intersect here too, suggesting that even in this respect there was no difference between the diversities of the two habitats.

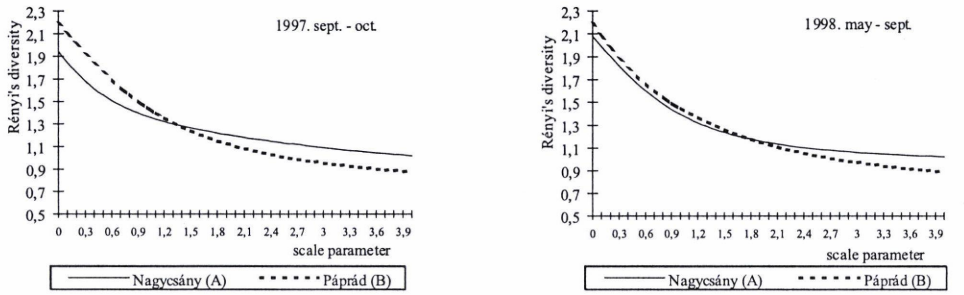

Fig. 9. Diversity ordering of the two habitats in 1997–1998

Spatio-temporal analysis of four rodent populations

In 1997, in the abandoned field near Nagycsány (plot **A**) the dominance of *M. arvalis* was registered based on "minimum number alive" values. Its population peaked in September. The *Apodemus* species did not show synchrony in their dynamics either with *M. arvalis* or with each other; *A. agrarius* had a peak as early as August. After the September peak of the other two *Apodemus* species, numbers of *A. sylvaticus* continued to grow, as opposed to *A. flavicollis* numbers which dropped. In 1998 this plot was characterised with the dominance of *M. arvalis* and *A. agrarius*, both species peaking in August. *A. sylvaticus* and *A. flavicollis* were found in small numbers throughout the year. It is well indicated by the MNA curve that in 1997 *A. agrarius* numbers grew gradually and peaked in November, whereas in 1998 the highest abundance occurred in August, after which decline followed (Fig. 10).

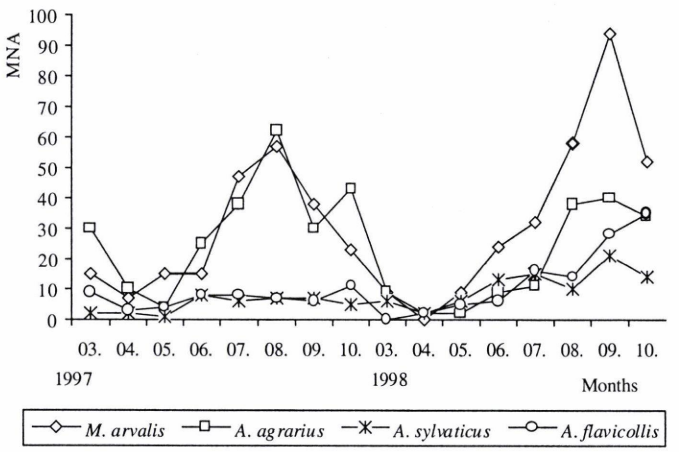

Fig. 10. MNA of the four rodent populations in habitat **A** (1997–1998)

In the Páprád area (plot **B**) trapping went on in 1997 through three months only, therefore the MNA values of the two years are shown within a single chart (Fig. 11). Since several months passed between trappings in the two years, the curve section between November

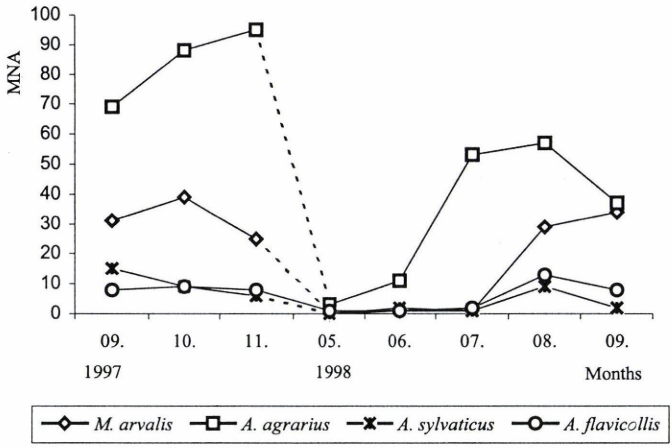

Fig. 11. MNA of the four rodent populations in habitat **B** (1997–1998)

1997 and May 1998, representing a pause in trapping, appears as dashed. *A. sylvaticus* and *A. flavicollis*, similarly to the other study plot, was captured in small numbers in both of the years. However, there were much less *M. arvalis* than in the Nagycsány sample area.

The trend of population changes in plot **A** was significantly similar in each of the cases when the MNA values of the six species-pairs in 1997 were compared using Spearman rank-correlation. In 1998 the trends of only *M. arvalis* and *A. agrarius* were significantly similar, while the rest of the pairs differed in this respect (Tab. 5). For plot **A** data from 1997 and 1998 were jointly evaluated: rank-correlation was performed for the MNA values of the eight months (Tab. 6). Interestingly, here there was difference between the demographic trends of *M. arvalis* and *A. agrarius*, while MNA trends of the rest of the species pairs were significantly correlated. As there were 8 months of trapping in the three-year-old abandoned area (plot **A**) in both study years, the MNA changes of the two periods could be compared based on the species pairs (Tab. 7). The demographic changes of the two years were considerably similar, despite that no significant rank-correlation values were obtained for the data of *A. agrarius* and *A. sylvaticus*.

Table 5. Spearman rank-correlation calculated for MNA values of species-pairs in the Nagycsány sampling area A in 1997–1998

Trapping years	1997		1998	
Species pairs	R_S	Significance	R_S	Significance
M. arvalis vs. A. sylvaticus	0.89	$P < 0.01$	0.51	NS
M. arvalis vs. A. flavicollis	0.83	$P < 0.01$	0.26	NS
M. arvalis vs. A. agrarius	0.98	$P < 0.001$	0.82	$P < 0.02$
A. agrarius vs. A. sylvaticus	0.87	$P < 0.01$	0.44	NS
A. agrarius vs. A. flavicollis	0.8	$P < 0.02$	0.59	NS
A. sylvaticus vs. A. flavicollis	0.92	$P < 0.001$	0.21	NS

Table 6. Spearman rank-correlation calculated for MNA values of species-pairs in the Páprád sampling area B in 1997–1998

Trapping years Species pairs	1997–1998 R_S	Significance
M. arvalis vs. A. sylvaticus	0.72	$P < 0.05$
M. arvalis vs. A. flavicollis	0.78	$P < 0.05$
M. arvalis vs. A. agrarius	0.57	NS
A. agrarius vs. A. sylvaticus	0.73	$P < 0.05$
A. agrarius vs. A. flavicollis	0.69	$P < 0.1$
A. sylvaticus vs. A. flavicollis	0.76	$P < 0.05$

Table 7. Spearman rank-correlation of the two study years based on MNA values of the six species-pairs in the Nagycsány sampling area A

Trapping years Species pairs	1997 vs. 1998 R_S	Significance
M. arvalis vs. A. sylvaticus	0.71	$P < 0.01$
M. arvalis vs. A. flavicollis	0.76	$P < 0.001$
M. arvalis vs. A. agrarius	0.82	$P < 0.001$
A. agrarius vs. A. sylvaticus	0.42	NS
A. agrarius vs. A. flavicollis	0.7	$P < 0.01$
A. sylvaticus vs. A. flavicollis	0.67	$P < 0.01$

In plot **A** in 1997 patchiness values were high in the first month of trapping, except for *A. agrarius*, which had a much lower value in the first month than the rest of the species, though its value was higher than 1.0, which would suggest random distribution (Fig. 12). In the remain-

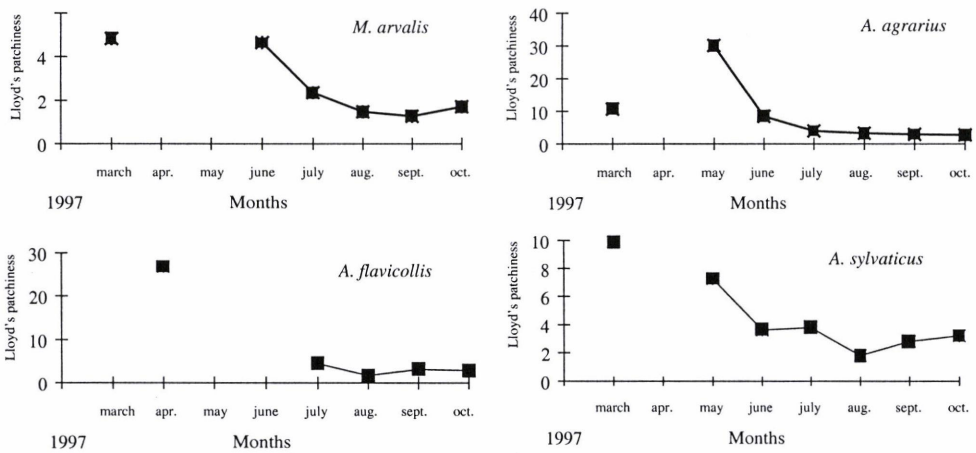

Fig. 12. Values of the aggregation index of the four populations in habitat **A** in 1997

ing months values were uniformly lower, though they implied aggregation in each case. In 1998 the value of the aggregation index decreased considerably from May onwards in *M. arvalis*, *A. sylvaticus* and *A. flavicollis*, yet they remained above 1.0, indicating aggregation (Fig. 13). In

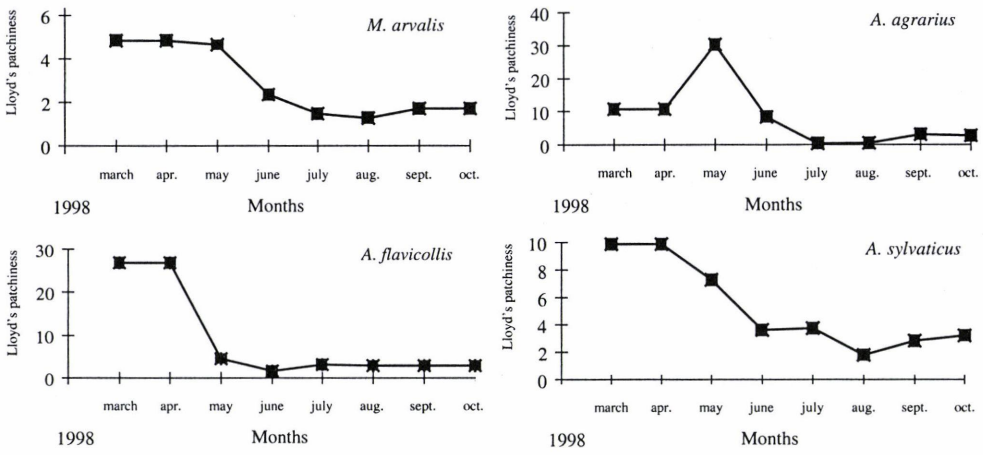

Fig. 13. Values of the aggregation index of the four populations in habitat **A** in 1998

A. agrarius it was highest in May, then it abruptly dropped to around 0, and in the second half of the summer the values indicated that individuals were segregated. An aggregated distribution had re-established itself by autumn. From the above it appears that individuals of the populations were clustered, which phenomenon remained characteristic even at high densities in the autumn. We tested for correlation between patchiness values and the number of individuals per hectare in all four species. In plot **A** in 1997 significant negative non-linear correlation was revealed by regression analysis for each of the species except for *A. flavicollis* (Fig. 14).

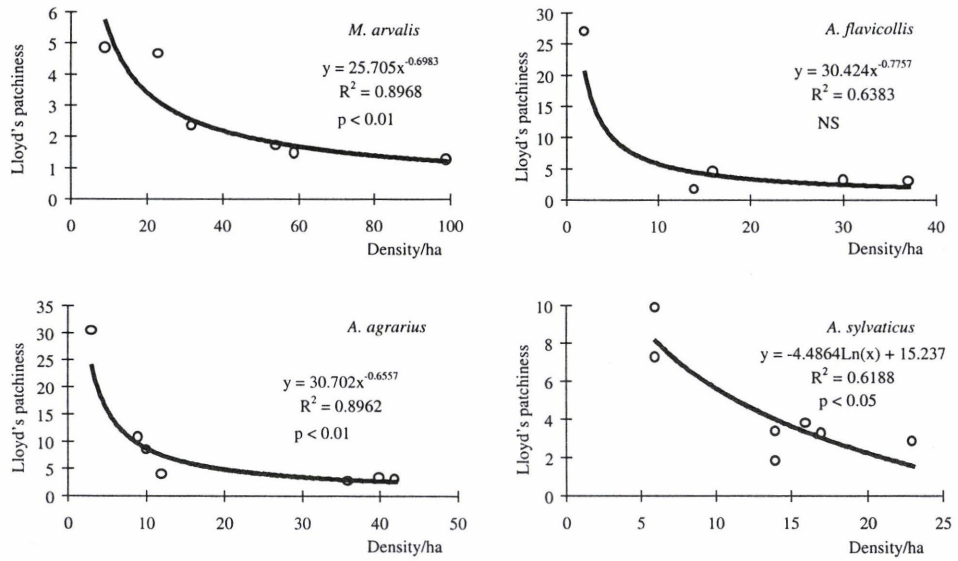

Fig. 14. Patchiness as a function of density of the four populations in habitat **A** in 1997

In 1998 the same significant negative relationship was characteristic of *A. agrarius* and *M. arvalis*. The regression curve was similar in *A. flavicollis* but it was not significant. In the *A. sylvaticus* population the growth of the number of individuals was in significant linear correlation with the decrease of patchiness values (Fig. 15).

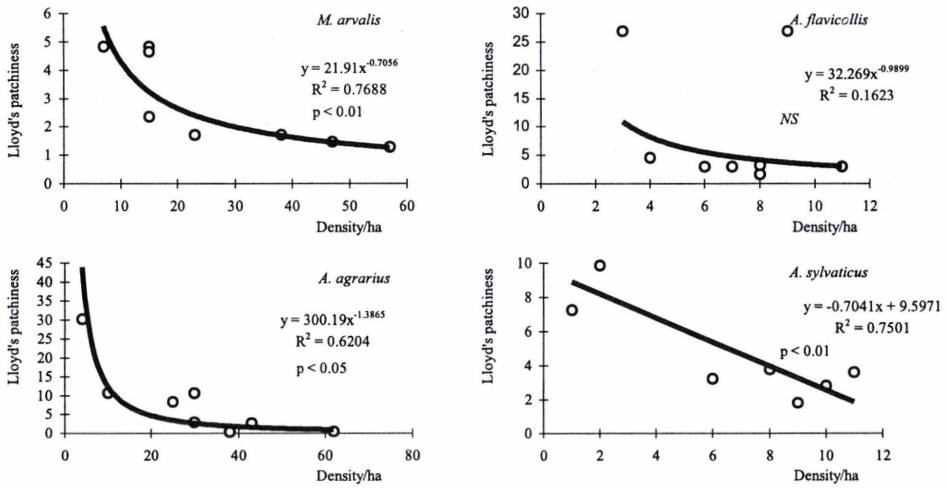

Fig. 15. Patchiness as a function of density of the four populations in habitat **A** in 1998

In plot **B** in 1997 the aggregation of individuals was general in all four species. The values of the index of aggregation decreased in all of the species except for *A. sylvaticus* which was present constantly in small numbers, thus *M. arvalis* and *A. agrarius* appearing as dominant species could cause the growth of its degree of aggreation, by forcing it out from certain locations. In 1998 patchiness values were the highest in May (Fig. 16), which can

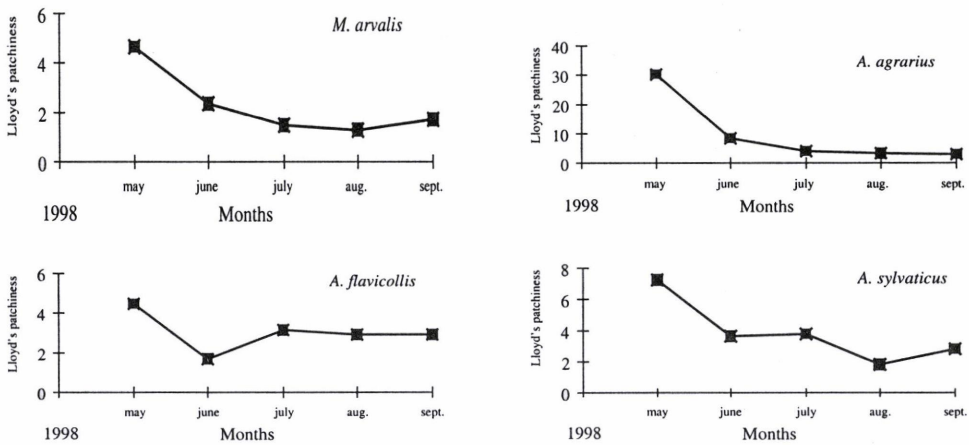

Fig. 16. Values of the aggregation index of the four populations in habitat **B** in 1998

be attributed to the generally very small amount of capture data. Among the four species it is *M. arvalis* in which the value of patchiness sinks the most, yet remaining in the range above 1.0, implying aggregation. Correlation between number of individuals and patchiness was tested for only in the five-month period in 1998 (Fig. 17). There was no signi-

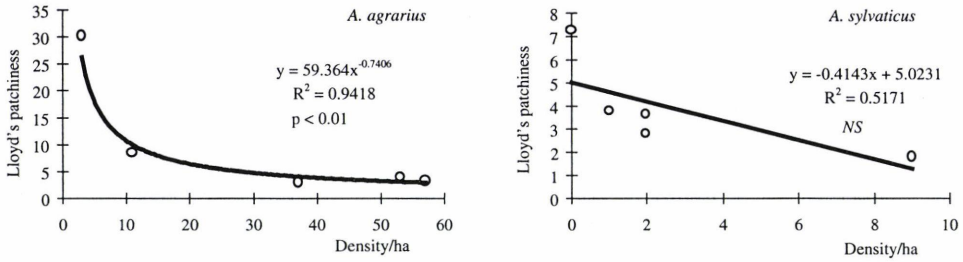

Fig. 17. Patchiness as a function of density of the two populations in habitat B in 1998

ficant correlation between these variables in the case of *M. arvalis* and *A. flavicollis*. Presumably this was strongly associated with the low capture rates. In *A. agrarius* a negative non-linear correlation was significant between the two parameters for this year. In *A. sylvaticus* a negative linear correlation, though not significant, characterised the relationship between the aggregation index and population size. The lack of significance is probably due to the shorter sampling period than in the other plot. Nevertheless, the regression analysis in this species revealed identical correlations in the two habitats.

Discussion

The small mammal faunas of the two studied open habitats appeared to be similar, which is primarily caused by the commonness of the dominant species. There was no considerable difference between the two habitats in respect of their diversities. However, it must be noted that diversity calculations and comparisons were performed only for a selected period, as in plot ***B*** there were less months of trapping. In the two areas differing in their successional stages the appearance and disappearance of certain individuals could be recorded already during our sampling period. In the five-year old area turning into a marsh, *Neomys* species preferring wet habitats appeared beside the *Crocidura* species, whereas in the three-year old abandoned land even the *Crocidura* species became more frequent only in the second study year. As the area was gradually loosing its ploughland character, burrows of *M. spicilegus* kept disappearing to an extent that in the second year very few specimens were captured. The closing and thickening of the vegetation, a phenomenon typical of both habitats, favoured *A. agrarius*. There are several hints in the literature that this species prefers areas close to water bodies or periodically inundated lands (Zejda 1967, Babinska-Werka *et al.* 1979, Chelkowska *et al.* 1985), which we can confirm with our findings. Palotás (1986), too, evaluated his sample areas by calculating Shannon-Wiener diversity, and similarly to us found higher diversity in areas periodically under water (e.g. backwater forests, flood embankments). Pelikán & Nesvadbova (1979) compared the communities of cultivated lands with those of sur-

rounding fields, and found six different species in two different habitats. Adamczewska-Andrzejewska *et al.* (1981) studied the demography of populations in a small mammal community with a very similar composition to that found in our abandoned field sample areas. *M. arvalis*, *A. agrarius* and *A. flavicollis* were reported as dominant species of the various cultivated sample lands. The population size of *M. arvalis* grew from spring to autumn (Adamczewska-Andrzejewska *et al.* 1981), while the populations of the other species within the community exhibited considerable differences in their maxima which, in addition, did not overlap. This phenomenon appeared also in our studies: we recorded the demographic maximum for *M. arvalis* in late summer (August-September), which finding corresponds to those reported by Butet and Leroux (1994). Similarly to the formerly cited Polish data, population maxima of the different species were not synchronous; besides the drop in *M. arvalis* numbers in autumn, the abundance of the *Apodemus* species, especially of *A. agrarius*, remained considerably growing for a while.

It was possible to test the density-dependence of Lloyd's aggregation index in both habitats, based on data of 8 and 5 months, respectively. Our results are in correspondance with Polish data from trapping in cultivated fields (Mackin-Rogalska 1981). We could record the decrease of the aggregation index as a function of growing population size in *M. arvalis* and *A. agrarius*. In two cases in *A. sylvaticus* these parameters were negatively correlated in the form of a linear trend.

We deem it important from a conservational aspect to study near-natural open habitats existing in various phases of succession. From the point of view of landscape ecology, these mosaic-like habitat fragments are crucial for the survival of the native small mammal populations and communities.

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